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(54) Title of Invention

Drilling apparatus

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Drilling apparatus

Field of the invention

This invention relates to drilling apparatus for drilling bore holes in the ground.

Summary of the invention

According to the invention drilling apparatus comprises a  
5 flexible enclosure located in a space defined between two  
members, the enclosure serving either as an actuator to  
control the direction of drilling by applying a radial  
force between the members resulting in radial displacement  
between the members, or serving as a pump to deliver fluid  
10 to actuating means for controlling the direction of  
drilling, as a result of variation of the spacing between  
the members.

When the flexible enclosure serves as an actuator, the  
enclosure is one of a plurality of such actuators disposed  
15 in said space which is annular. Preferably, the actuators  
apply a deflecting force which has a controlled magnitude  
and direction and which deflects a drilling tube of the  
drilling apparatus.

When the flexible enclosure serves as a pump, the spacing  
20 between the members conveniently varies as a result of  
rotation of an eccentric member. The eccentric member may  
rotate with a drilling tube and the flexible enclosure is  
located between a bearing sleeve and an outer casing, the

bearing sleeve being non-rotatable and being mounted on the eccentric member by a bearing.

In the preferred embodiment to be described, drilling apparatus has a plurality of actuators, each in the form of a flexible enclosure, and a pump also in the form of a flexible enclosure, the pump supplying fluid to selected actuators at a controlled pressure in dependence upon the required magnitude and direction of the deflecting force to be applied to the drilling tube.

10 Drilling apparatus according to the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic view of the bottom hole assembly of the drilling apparatus,

15 Figure 2 is a detailed view of part of Figure 1,

Figure 3 is a sectional view on the line III-III of Figure 2,

Figure 4 is a detailed view of another part of Figure 1, and

20 Figures 5, 6 and 7 are respectively side, end and plan views of a flexible enclosure of the drilling apparatus.

#### Detailed description of the drawings

Referring to Figure 1, the drilling apparatus comprises a rotatable drilling tube 10 carrying at its extremity a drilling bit 12. The drilling tube 10 is supported and

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centred in a bore hole 14 by two stabilisers 16, 18 and by a third, optional stabiliser 20. Between the stabilisers 18 and 20 is a control module 22 which effects controlled deflection of the drilling tube 10 to vary the drilling course or direction. In Figure 1, the undeflected drilling tube is indicated at 24, the deflected drilling tube at 26 and the variation in drilling angle at 28. The arrows 30 depict the reaction forces applied by the bore hole wall to the drilling tube 10, but the reaction to the deflecting force is resisted principally within the control module 22, as will be explained.

The module 22 has a cylindrical casing 32 having end seals 34 and enclosing bearings 36, 38 and actuating means 40 for deflecting the drilling tube 10. Referring to Figures 2 and 3, the actuating means 40 comprise four flexible enclosures in the form of bags 42 located in the annular space between the casing 32 and a bearing sleeve 44. The bearing sleeve 44 does not rotate with the drilling tube 10 but is mounted on the latter by bearings 46. Fluid is fed to the bags 42 through hydraulic pipes 48 which communicate with a pump (50, Figure 4) through a valve block and reservoirs unit 52.

The pump 50 is located in the annular space between the casing 32 and a bearing sleeve 54 which is non-rotatably mounted on the rotatable drilling tube 10 by a bearing 56. Between the drilling tube 10 and the inner race of the bearing 56 is located an eccentric sleeve 58 which rotates with the drilling tube 10 and causes the bearing sleeve 54 to oscillate in the radial direction of arrow X in Figure 4, thereby to apply a pumping action to a flexible enclosure or bag 60 of the pump. The flexible bag 60 is similar in construction to one of the flexible bags 42. An

anti-rotation pin 62 interconnecting the casing 32 and the bearing sleeve 54 prevents rotation of these two components.

- 5 Figures 5, 6 and 7 show the construction of a representative bag 42 or the bag 60. The bag 42 or 60 has a fabric body formed into a tubular configuration, opposite edges being sealed by metallic clamping strips 64, from one of which extends a hydraulic supply or return pipe forming the hydraulic pipe 48.
- 10 The magnitude and direction of the deflecting force applied by the bags 42 to the drilling tube are controlled by appropriate control of the application of hydraulic pressure from the pump by 60 to the actuator bags 42. In order to achieve the required deflecting force, two
- 15 adjacent bags 42 are individually pressurised to the required extent, and the two remaining bags 42 are completely depressurised, this being achieved by appropriate energisation of the valves in the valve block and reservoirs unit 52.
- 20 As mentioned, the deflecting force is applied to the drilling tube, in the desired magnitude and direction, to impart a curvature to the tube, as indicated at 26 in Figure 1. This controlled curvature controls the drilling direction. The reaction to the deflecting force is borne
- 25 within the casing 32, the bearings 36, 38 providing reactive forces on the tube. It will be noted that the bore hole wall provides no reactive forces to the tube 10 through the intermediary of the casing 32.
- 30 Attention is drawn to the applicants' specifications GB-A-2177738 and GB-A-2172325 which disclose similar apparatus.

Claims

1. Drilling apparatus comprising (a flexible enclosure located in a space defined between two members, the enclosure serving either as an actuator to control the direction of drilling by applying a radial force between  
5 the members resulting in radial displacement between the members), or serving as a pump to deliver fluid to actuating means for controlling the direction of drilling, as a result of variation of the spacing between the members.
- 10 2. Drilling apparatus according to claim 1, wherein the flexible enclosure serves as an actuator and is one of a plurality of such actuators disposed in said space which is annular.
3. Drilling apparatus according to claim 2, wherein the  
15 actuators apply a deflecting force which has a controlled magnitude and direction and which deflects a drilling tube of the drilling apparatus.
4. Drilling apparatus according to claim 3, wherein there are four actuators equi-angularly positioned around the  
20 longitudinal axis of the drilling tube.
5. Drilling apparatus according to claim 3 or 4, wherein said members are a casing and a bearing sleeve, the bearing sleeve being non-rotatable and being supported by means of bearings on the drilling tube.

6. Drilling apparatus according to claim 1, wherein the flexible enclosure serves as a pump and the spacing between the members varies as a result of rotation of an eccentric member.

5 7. Drilling apparatus according to claim 6, wherein the eccentric member rotates with a drilling tube and the flexible enclosure is located between a bearing sleeve and an outer casing, the bearing sleeve being non-rotatable and being mounted on the eccentric member by a bearing.

10 8. Drilling apparatus according to claim 6 or 7, wherein the flexible enclosure serving as a pump feeds a plurality of actuators each constituted by a flexible enclosure as specified in any of claims 2 to 5.

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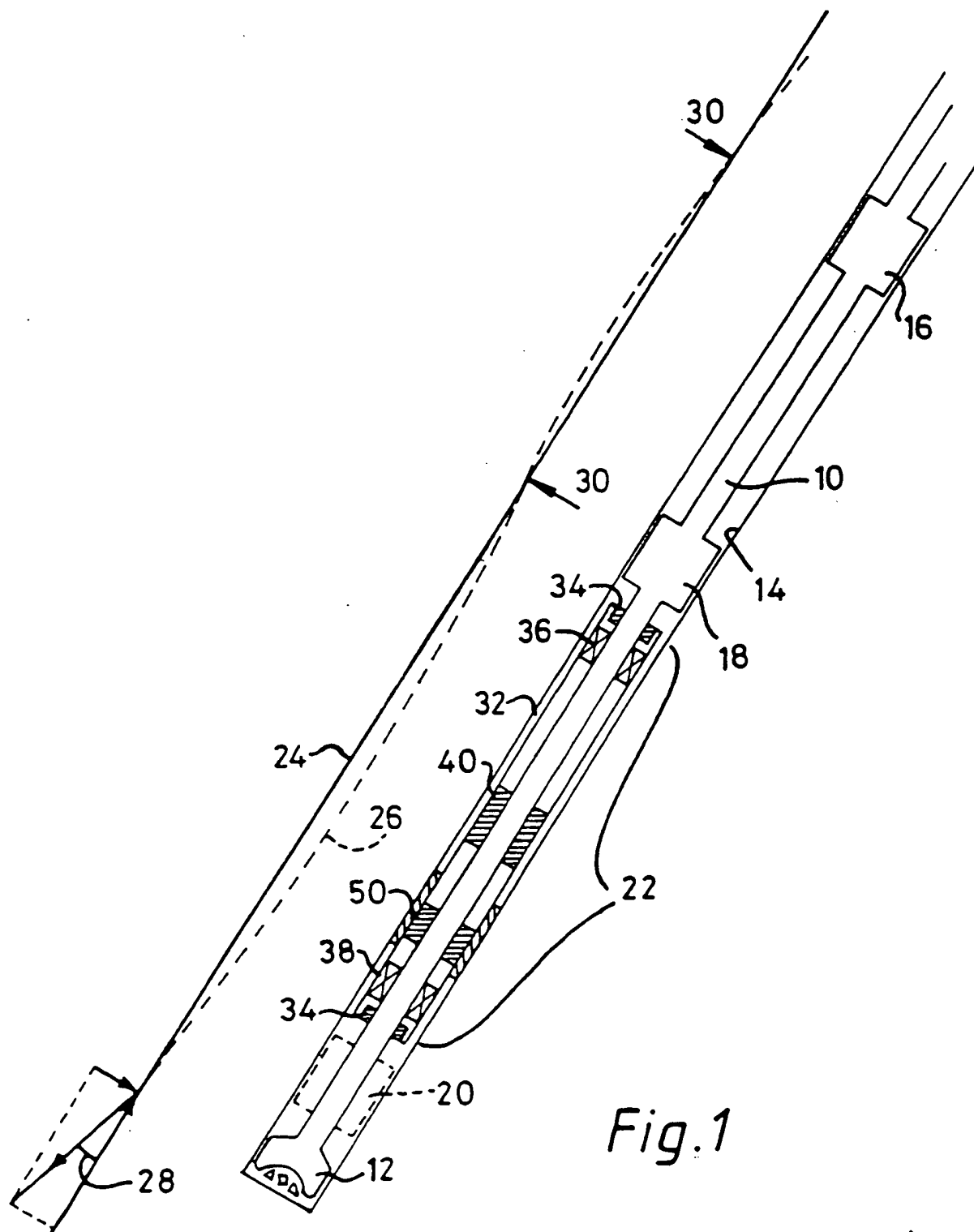


Fig. 1

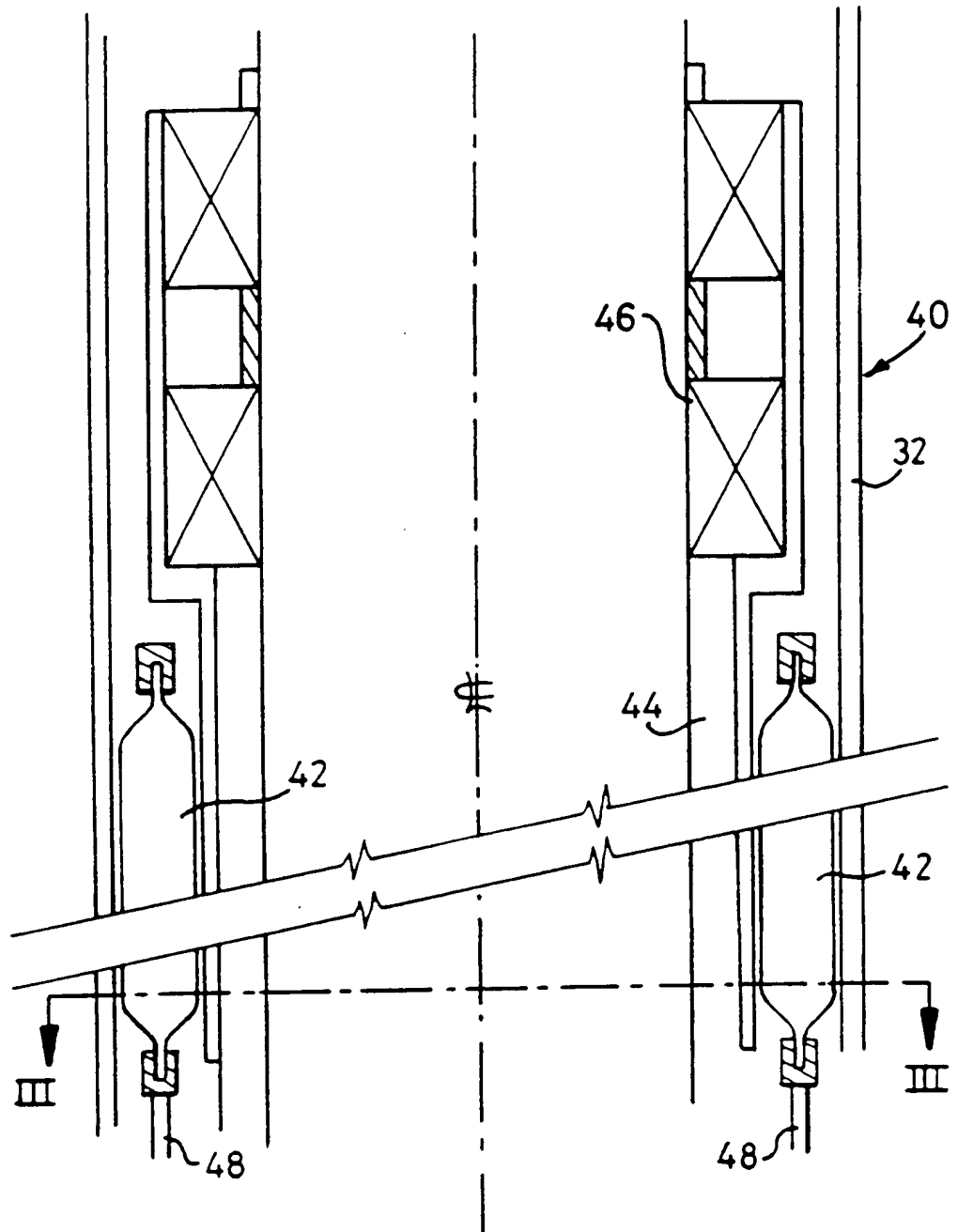
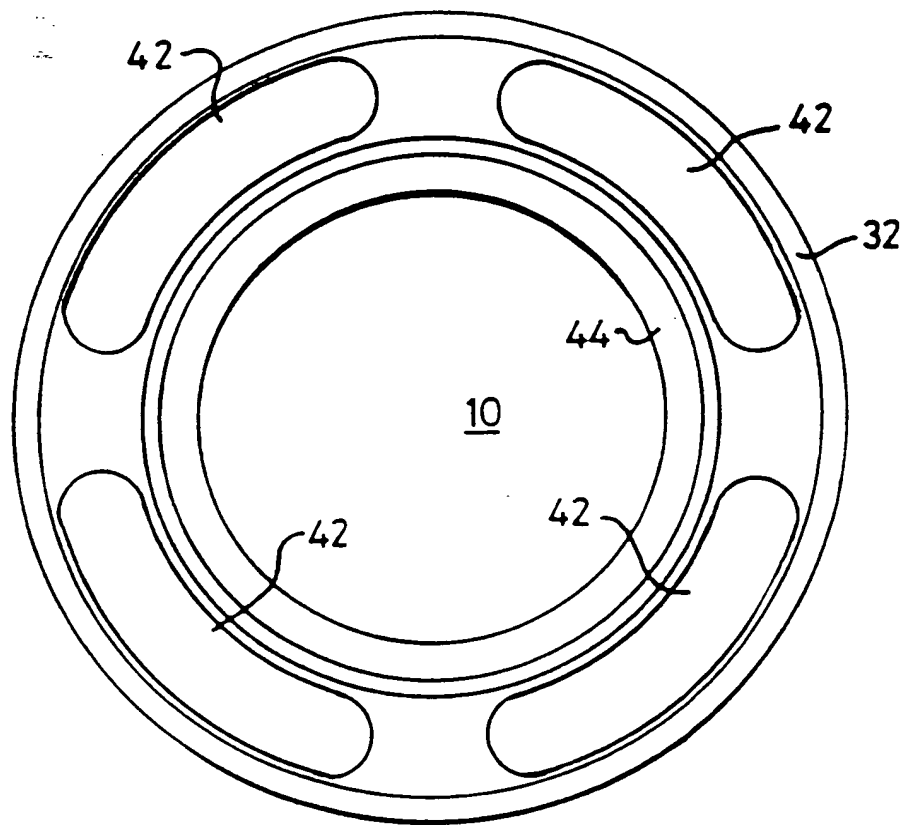
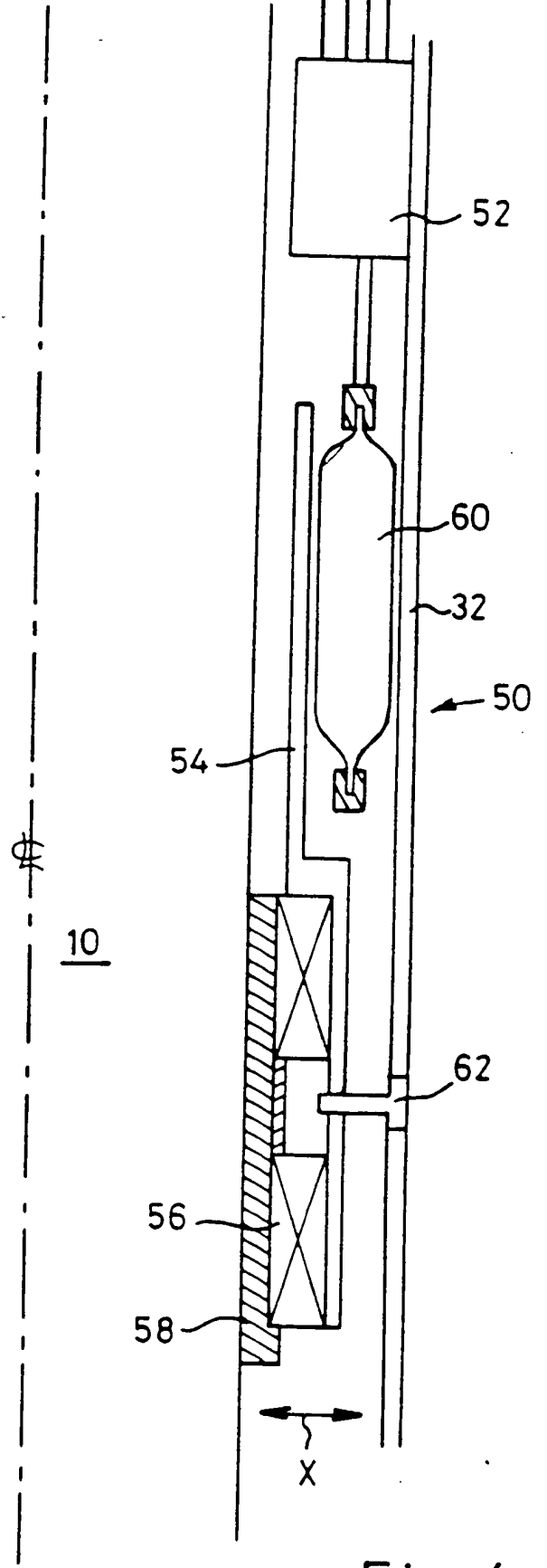
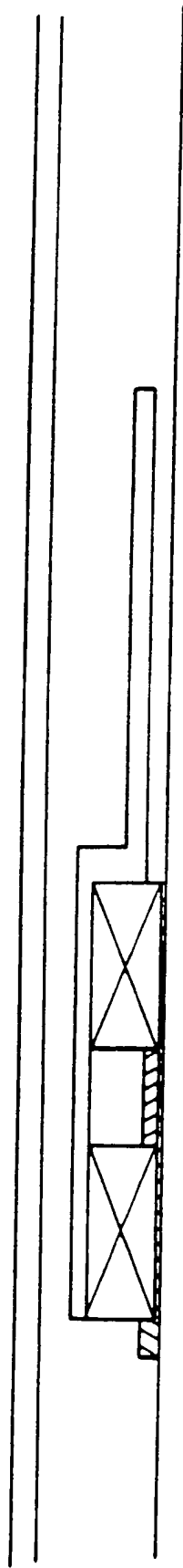


Fig. 2

*Fig. 3*



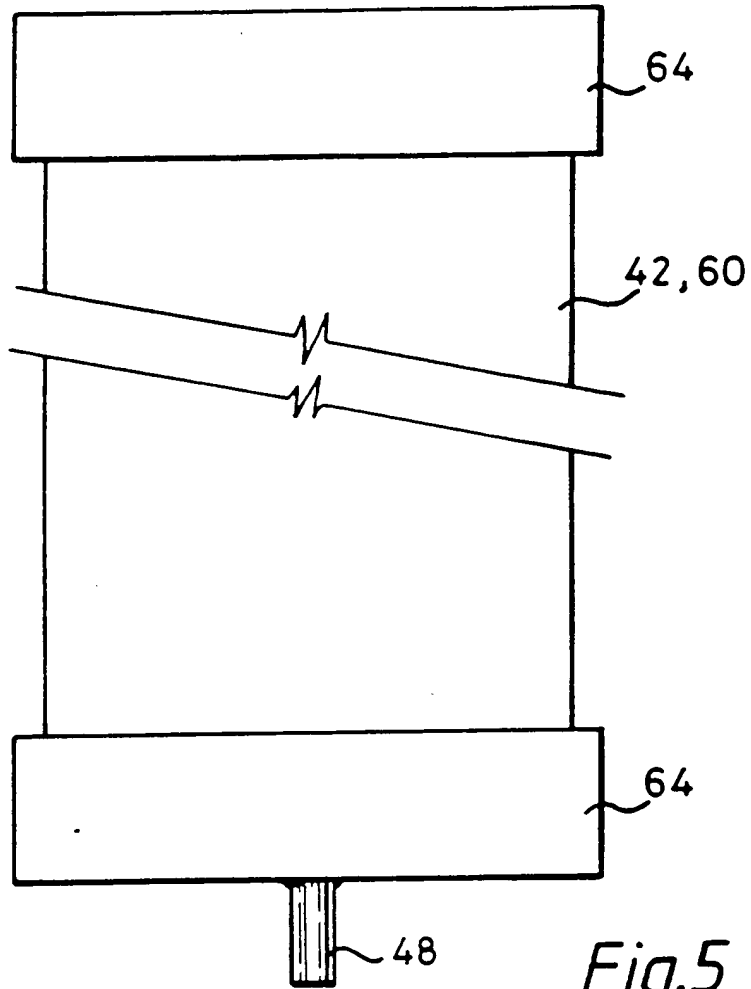


Fig. 5

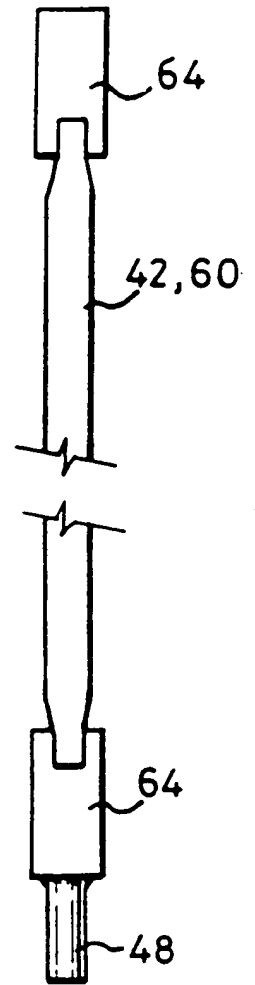


Fig. 6

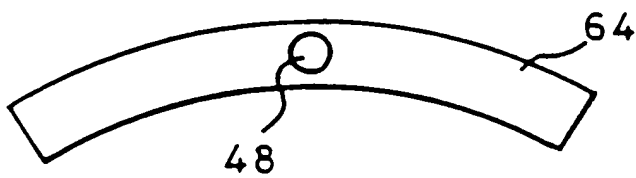


Fig. 7